

plopods, again, the legs are equal, and terminate in a simple claw, which is not the case in *Pauropus*. The mouth-parts, though very different from those of the Chilopods, are perhaps even less like those of the Diplopods. The eyes and antennæ are also very different.

Thus, then, *Pauropus* differs greatly from either of the two great orders of Centipedes. It forms a connecting link not only between the Myriapods and other Articulata, but also between the Chilopoda and Diplopoda.

III.—On the Sap-currents (Rotation and Circulation in the Cells of Plants), with reference to the question of Contractility. By Professor REICHERT*.

THE results of my investigations may be summed up in the following paragraphs:—

1. In all vegetable cells with rotating, circulating, or rotato-circulating currents, two parts are to be distinguished in the contents of the cellulose capsule—namely, the central “cell-juice” or “cell-fluid” situated in the axis, and the “mantle-layer” (*Mantelschicht*) diffused between this and the cellulose capsule.

2. The “cell-fluid” is colourless, or coloured as in *Tradescantia virginica*, not very tenaciously fluid, and without albumen, but not well known as regards its other chemical properties; with respect to the circulation, it is the motionless, resting part of the cell-contents.

3. To the “mantle-layer” belong the following constituents:—the “mantle-fluid” as I have called it, the tenaciously fluid substance named “protoplasm” by Hugo Mohl; chlorophyll corpuscles, and other very small solid corpuscles, the chemical nature of which cannot be ascertained positively; the cell-nucleus; microscopic crystals; and the primordial utricle when this is present, which would form the boundary of the “mantle-layer” towards the cellulose capsule.

4. In the Characeæ the “mantle-fluid” cannot be overlooked; it was, however, erroneously assimilated to the tenacious fluid substance of circulating sap-currents, the so-called protoplasm-currents, and rightly distinguished only by Nägeli. In the cells with circulating sap-currents, it was first detected by E. Brücke in the stinging-hairs of *Urtica urens*; and it was observed in all the cells with rotating or circulating sap-currents examined by me. It is diffused between the cell-juice and the cellulose capsule, or the primordial utricle when this is present, is fluid, rich

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in water, exhibits only a small amount of albumen, and does not mix with the cell-juice. Its saline contents and the presence of other organic substances dissolved in it cannot be accurately ascertained; but it may be taken as a matter of course that it is in chemical reciprocal action with the other constituents of the mantle-layer.

5. The other constituents of the mantle-layer are bathed by the mantle-fluid or suspended in it. Amongst the constant ones, leaving out of consideration the questionable primordial utricle, are the viscid substance and the chlorophyl and other small corpuscles. The "viscid substance" is strongly albuminous, more or less tenacious as regards its state of cohesion, and presents itself in different and variable arrangement and form before and during the flow of the sap. Neither the nucleus nor the microscopic crystals are always to be found. Among the crystals were observed irregularly stellate ones of unknown chemical constitution (*Hydrocharis morsus ranae*), and, in the stinging-hairs, oxalate of lime.

6. In the currents of the vegetable cell only the constituents of the "mantle-layer," not including the primordial utricle, take part. But whatever be the causes or forces by which these phenomena are produced in the constituents of the "mantle-layer," their action is demonstrably exerted especially, and exclusively, on the "mantle-fluid," which has hitherto remained quite unnoticed; this is thereby set in a rotatory streaming motion. The movements of the other constituents of the mantle-layer (the viscid substance, nucleus, chlorophyl and other small corpuscles, and microscopic crystals) are induced by the mechanical action of the rotating mantle-fluid upon them, with the cooperation of adhesion and, in the case of the viscid substance, of cohesion. The molecular movements of very small chlorophyl and other corpuscles visible under favourable circumstances remain excepted therefrom.

7. The rotatory movement of the mantle-fluid, as also its direction, is recognized especially from those constituents of the mantle-layer which float freely in it and are set in motion by it, namely the freely moving chlorophyl and other solid corpuscles, and this both in the cells with rotation and in those with a so-called circulation. In the *Charæ* and in *Hydrocharis morsus ranae* the viscid substance is also set in motion in separated fragments, in the *Charæ* in a globular form, and the current is then called "rotation."

8. The rapidity of movement of the freely floating and rotating substances under otherwise similar circumstances is secondarily dependent upon their mass, as also upon the influences of adhesion, which make themselves felt at the limit of

the cell-juice, and still more strikingly at the cellulose capsule and during the mutual contact of the floating constituents. In consequence of the operation of adhesion, it may also happen that the constituents passively carried on become momentarily or more permanently quiescent, or even acquire retrograde movements.

9. The mechanical action of the rotating mantle-fluid reveals itself also by the change of appearance and form of the viscid substance ("protoplasm"), both in its freely swimming state (*Hydrocharis*) and also especially during its adherence to the cellulose capsule, whether transitory or permanent, in the neighbourhood of the nucleus or in some other favourable spot (*Hydrocharis*, *Urtica urens*, *Tradescantia*, &c.). These changes of appearance resemble in external aspect the motory forms of contractile tissues; they are, however, caused by the quite unavoidable action of the rotating mantle-fluid upon the viscid substance, are often demonstrably combined with a permanent displacement of the mass, and cannot be regarded as the effect of molecular movements of the particles in the substance itself.

10. It is a matter of course, and will also be established by direct observations, that the viscid substance diffused upon and adhering to the cellulose capsule in the vicinity of the nucleus or in any other spot, when in a favourably tenacious state of cohesion, will be drawn out by the mechanical action of the rotating mantle-fluid into long filaments or cords, either simple or branched, and either terminating in free extremities or uniting again in circular or elliptical forms, and converted by the co-operation of adhesion into a more or less complicated net diffused between the cellulose capsule and the cell-juice. This is the arrangement and configuration of the viscid substance in the cells of plants with a so-called circulating or circulo-rotating current; and this is the foundation of the so-called "protoplasmic currents" so often spoken of. When the viscid substance is thus arranged, the free-swimming granules very easily get into the domain of its fibres and cords, and may even disappear entirely from the open region of the mantle-fluid, and in the struggle between the influences of the rotating mantle-fluid and of adhesion perform such vacillating and leaping movements as to remind one of the so-called "granular movement" of contractile substances. Lastly, in this arrangement the viscid substance may be set in motion in the region of its fibres and cords, as is proved by the progression on the fibres of swellings with imbedded granules or crystals; but the tenacity of the substance may be so considerable, and the power of the rotating fluid so small, that such a movement either does not take place at all, or not through the whole extent of the net (E. Brücke).

11. The structure of the ramified and net-like configuration of the viscid substance depends chiefly upon the degree of force of the rotating mantle-fluid, the form of the cellulose capsule, the point of attachment of the viscid mass on the cellulose capsule and its relative position to the axis of rotation of the mantle-fluid, and, lastly, upon its state of cohesion.

12. There is no essential difference between the rotating, circulating, and rotato-circulating currents of the cells; in all, the rotating mantle-fluid is to be placed in the foreground; in it alone we can recognize the direct influence of the unknown causes of the currents, and this everywhere acts in the same way.

13. The other constituents of the "mantle-layer" exposed to the mechanical influence of the rotating mantle-fluid cause the current of the vegetable cell to vary in outward appearance; they will also, of course, present varying obstacles to it according to circumstances. Among the phenomena of this nature I may indicate that in the cavities formed between the resting masses of the viscid substance the rotating mantle-fluid may come to perfect rest, and that then molecular movements of free granules are detected in such cavities,—further, that in *Hydrocharis morsus ranae* the rotating mantle-fluid is divided into two regular rotating currents, running down separated from each other by a distinct piece traversing the cavity of the cellulose capsule,—and, lastly, that by means of such impediments at the rounded poles of the cellulose capsule reflux movements of the currents of the most various kinds may be produced.

14. Motory phenomena from which the existence of a contractile activity in the viscid substance or in the other constituents of the cell-contents might be deduced, are entirely wanting in the plant-cells with currents investigated by me.

15. With regard to the movements of currents in the cells of plants, the first thing to be done is to discover the causes by which the rotating movements of the "mantle-fluid" are produced. But no physical or chemical processes by which this rotating movement might be brought about have hitherto been detected in the cells of plants.

IV.—*Conclusive Proofs of the Animality of the Ciliate Sponges, and of their Affinities with the Infusoria flagellata.* By H. JAMES-CLARK, A.B., B.S.*

BEFORE I proceed to the main point in question in this article, I wish to say a word in regard to the group of animals, viz. the PROTOZOA, of which I am fully convinced the *Spongiae ciliatae* are a part.

* From 'Silliman's American Journal, Nov. 1866.